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II. LEC INPUT PRICES GROW AT THE SAME RATE AS U.S. INPUT PRICES

The X in a price cap plan should be chosen so that *GDP-PI - X* is a reasonable target for the future change in cost per unit of output for the regulated firm. Measurement of LEC and U.S. input price changes is thus necessary in order to translate changes in relative growth of total factor productivity (TFP)—which relate growth rates of output and input *quantities*—to relative changes in unit *costs*, which requires reliable information about input prices. Put simply, changes in cost per unit of output are given by the difference between the change in cost and the change in output quantity. Since the change in cost is simply the sum of the change in input price and input quantity, the change in cost per unit of output can be written as the difference between the growth of input prices and the growth of TFP.

The *FFN* seeks comments on three items related to the measurement of LEC and U.S. input prices and their role in the selection of an appropriate target value for X:

- Is the long-term difference between U.S. and LEC input price growth rates (the "input price differential") zero?

- Has the trend in LEC input prices or the input price differential changed since divestiture?

- Is it more desirable to measure LEC unit cost growth directly, rather than by comparing LEC TFP and input price growth to U.S. TFP and input price growth?

Our analysis once again confirms that the long-term trend of the LEC and U.S. input price differential is zero and that the trend has not changed since divestiture. We continue to believe that capital service prices are difficult to determine and, while adequate for their intended use in a TFP study, will result in historical input price growth differences that

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cannot be calculated with sufficient accuracy to support forecasts of future input price growth differences.

A. The Long-Term Trend of The Input Price Differential is Zero

There is no genuine dispute in this proceeding that the long-term rate of growth of LEC input prices is the same as U.S. input price growth. As discussed in the attachment to the United States Telephone Association filing prepared by Christensen Associates, the input price series that is most methodologically consistent over time was filed in an affidavit by Dr. Laurits Christensen on February 1, 1995.[1] It combines (i) the Christensen Bell System study[2] for the 1949-1979 period, (ii) the USTA LEC study[3] for the 1984-1992 period, (iii) the Bellcore Report[4] for the 1980-1982 period and (iv) the North Dakota study[5] for the 1983-1984 period. In this data set (which we will call "Christensen 1" for convenience), the long run input price differential averages 0.1 percent and is not statistically significantly different from zero at conventional confidence levels.

In Appendix F to the *First Report and Order*, FCC Staff members C. Anthony Bush and Mark Uretsky (henceforth "Bush-Uretsky") cite a NERA analysis of a different set of Christensen data spanning the 1960-1992 period, which combines input price data from the Christensen LEC study for 1984-1992 and the Christensen North Dakota study for 1960-1984.[6] For convenience, we will label this data set "Christensen 2." Bush-Uretsky observe

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[1] L.R. Christensen, "An Input Price Adjustment would be an Inappropriate Addition to the LEC Price Cap Formula," Affidavit filed in CC Docket No. 94-1, February 1, 1995, Exhibit A (Christensen Affidavit).

[2] L.R. Christensen, D.C. Christensen, and P.E. Schoech, "Total Factor Productivity in the Bell System, 1947-1979," Christensen Associates, September 1981.

[3] L.R. Christensen, P.E. Schoech, and M.E. Meitzen, "Productivity of the Local Operating Telephone Companies Subject to Price Cap Regulation, 1993 Update," Christensen Associates, January 1995.

[4] Bell Communications Research Inc., *Econometric Estimation of the Marginal Operating Cost of Interstate Access*, Special Report SR-FAD-0900552, May, 1987.

[5] L.R. Christensen, "Total Factor Productivity Growth in the U.S. Telecommunications Industry and the U.S. Economy, 1951-1987," Schedule 3 to Direct Testimony, Case No. PU-2320-90-149, North Dakota Public Service Commission, 1990; U.S. Bureau of Labor Statistics, "Multifactor Productivity for the Private Business Sector."

[6] C.A. Bush and M. Uretsky, "Input Prices and Total Factor Productivity," *In the Matter of Price Cap Performance Review for Local Exchange Carriers, First Report and Order*, CC Docket 94-1, FCC 95-132 (March 30, 1995), Appendix F (henceforth "Appendix F").

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that this input price differential series differs from Christensen 1 and that the average input price differential over the 1960-1992 period is larger than that for Christensen 1, averaging 0.7 percent. Bush-Uretsky's conclusion that "the various data series placed on the record by USTA are not all in accord that the long-run input price differential is, in fact, zero"[7] is based entirely on the Christensen 2 data set. They both use Christensen 1 and 2 data sets to argue that "the post-divestiture period represents a significant break from the past."[8]

The Christensen 2 data set was put together by NERA from publicly-available sources to test the hypothesis that the average input price differential was zero in the long run. However, as explained by Dr. Christensen, there are important differences in the measurement of input prices between the USTA LEC and the North Dakota studies. Hence, the Christensen 1 data set provides "the most theoretically consistent telephone input price time series available" because it minimizes the use of the North Dakota input price data for which capital prices were calculated using a different method.[9] Thus Bush-Uretsky's conclusion that because

> Christensen has provided no justification for using a different version of the
> LEC input price series for the period 1960-1984 than NERA's version...we
> cannot accept Christensen's conclusion that the input price differential is
> zero[10]

is incorrect. Using the best available, most consistent measure of LEC input prices over the longest period available at the time, the difference between the growth rates of LEC and U.S. input prices is negligible (0.1 percent) and not statistically significantly different from zero.[11]

To test whether there is a statistically discernible difference between LEC and U.S. industry input prices, we performed four separate t-tests of the hypothesis that the mean

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[7] *Ibid*, at 12.

[8] *Ibid*, at 13-14.

[9] See the attachment to the United States Telephone Associating filling prepared by Christensen Associates.

[10] Appendix F at 13.

[11] However, as Dr. Christensen notes, there are significant methodological inconsistencies between the U.S. input inflation measure and his LEC input inflation estimates.

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difference between the change in LEC (or telecommunications) input prices and U.S. industry input prices is zero assuming unequal variances. Table 1 shows that we cannot reject the hypothesis at the 95 percent confidence level, as each t-statistic is less than its associated critical value. Indeed, even at the 90 percent confidence level, we cannot reject the hypothesis that the input price differential—for the entire period or for the post-divestiture period—is zero. Thus, the data provide no statistically valid support for the use of an average input price differential different from zero. In other words, Christensen's conclusion that the LEC input price differential is zero *is* supported by the data.

Table 1. We Cannot Reject the Hypothesis that LEC and U.S. Industry Input Prices Are Equal

Study	Time period	Telco Mean Input Price Differential	U.S. Industry Mean Input Price Differential	t-Statistic	t Critical $\alpha = 0.05$, 2 tail
Christensen 1	1949-1992	4.7%	4.8%	0.06	1.99
Christensen 1	1985-1992	1.7%	4.0%	1.27	2.36
Christensen 2	1960-1992	4.7%	5.3%	0.79	2.01
Christensen 2	1985-1992	1.7%	4.0%	1.31	2.36

We performed our tests using both the Christensen 1 and Christensen 2 data sets. Again, the tests show that we cannot reject the hypothesis that the two series have the same mean over the longest possible periods: 1949-1992 for the Christensen 1 data and 1960-1992 for the Christensen 2 data. From these tests, we conclude that there is no evidence that the long-term input price growth rates for the LEC industry and U.S. industry in general are

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different, and that no difference should be embodied in a value of X intended to represent a long-term industry average productivity target.

B. The Input Price Differential Did Not Change Permanently at Divestiture

Bush-Uretsky conclude that the post-divestiture average input price differential "is not consistent with a long-run trend of zero percent" and that "the input price differential for the post-divestiture period should be calculated using post-divestiture data." In addition, they assert—circularly—that "the input price differential for the 1984-1990 period should be based on data from that period" and that "[f]or purposes of calculating the historical X-Factor for the period 1984-1990 under a TFP framework, ...the input price differential for the 1984-1990 period should be used."[12] Under dispute is the robustness of that point estimate and whether it should be used as a forecast of future input price differentials. A key piece of evidence used to reach their conclusion is their test of Ad Hoc's unsupported hypothesis that divestiture explains the slow-down in LEC input prices relative to U.S. input prices during the 1984-1992 period:

> We tested Ad Hoc's hypothesis that divestiture explains why LEC input prices
> appear to be growing at a substantially slower rate than economy-wide input
> prices during the 1984-1992 period....We performed several statistical
> tests...we conclude that divestiture is a major factor in slowing the rate of
> growth of telephone company input prices [13]

Bush-Uretsky claim to have tested two hypothesized relationships: (i) that changes in LEC input prices can be explained by U.S. input price changes, the level of Moody's public utility bond yields and the implementation of divestiture, and (ii) that changes in the LEC and U.S. input price differential can be explained by the level of Moody's public utility bond yields and divestiture. Simple ordinary least squares regression was applied to test each

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[12] Appendix F at 13-14.
[13] Appendix F at 13.

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hypothesized explanation using both the Christensen 1 and 2 data sets described above, so that a total of four regression models were estimated.[14]

       There are clear conceptual and statistical problems with the analysis performed by Bush-Uretsky. First, the Bush-Uretsky approach cannot be used to conclude that divestiture had any *causal* effect on either LEC input prices or the LEC and U.S. input price differential. Empirical economic analysis begins with an economic model that describes the relationships among economic agents, markets and economic activity. While a divestiture dummy variable is statistically significant in all four of their regressions, this result does not establish the hypothesis that changes in LEC input prices are related to divestiture, that the input price differential increased permanently at divestiture or that divestiture caused any change in LEC or U.S. input prices. The data appear to support the hypothesis that a temporary shift took effect between 1984 and 1990 but then reverted back to the normal historical pattern of input price changes. Indeed, simply adding an additional dummy variable to their equations to account for the 1990-1992 period would indicate that the relationship shifted back again so that the slower LEC input price growth rate in the 1984-1990 period should be regarded as an aberration, not a permanent change. See Attachment A. The fallacy of this type of reasoning—introducing a dummy variable into a regression with no theoretical support and inferring something from a statistical test of its coefficient's significance—was explained in a California proceeding by Dr. Gregory M. Duncan.[15] As illustration, using dummy variables and the Bush-Uretsky data set, Duncan showed (i) that the input price differential in the 1983-1992 period was no different from the 1960-1982 period, (ii) that the

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[14] The Christensen 2 data spanned 1960 to 1992 while the Christensen 1 data spanned 1949 to 1992. Bush and Uretsky reported that the binary variable used to represent divestiture was equal to "zero" for all years prior to 1984 and equal to "one" for 1984 through 1992.

[15] Direct and Reply Testimony of Dr. Gregory M. Duncan on behalf of GTE California Incorporated in California Public Utilities Commission Case No. I. 95-05-047. Dr. Duncan shows that Bush-Uretsky were, in fact, unable to test the hypothesis of whether the LEC and U.S. input price series deviate from one another in the long run for two reasons. First, both the U.S. input price series and the Moody bond yield series are endogenous in the model, and second the Bush-Uretsky procedure misuses dummy variable methodology. Dr. Duncan performed an ARIMA analysis and a cointegration test between Christensen's LEC and U.S. input price series and, based on that analysis, concluded that the input series are cointegrated—that there is no evidence to support the contention that LEC input price series moves differently from the U.S. input price series except for spurious random fluctuations.
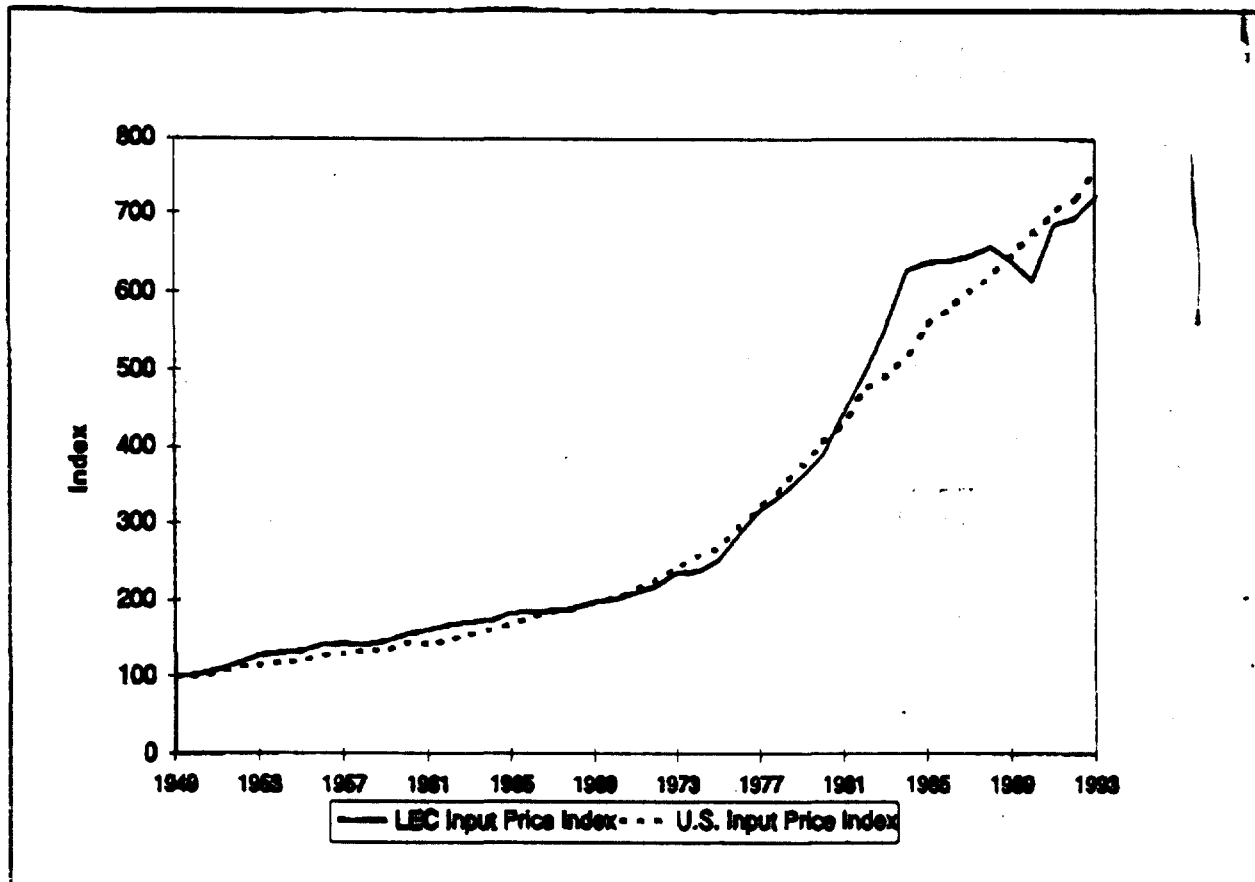
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Figure 1
LEC and US Input Prices Track Each Other Closely

input price differential has returned to a zero mean in the 1989-1992 period and (iii) that the
input price differential in the 1960-1980 period is the same as the differential in the 1990-
1992 period. Thus, further applications of the Bush-Uretsky dummy variable method show
that the Bush-Uretsky data do not support the hypothesis of a one-time shift in the input price
differential at divestiture.[16]

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[16] Duncan does not regard any of these dummy variable tests as dispositive tests of the hypothesis that
the input price differential changed at divestiture or differs from zero. In Duncan's view, the proper test of the
hypotheses that the input price differential is zero and has not changed is to perform a time series analysis of the
differential and test whether the series is stationary and has a zero mean. In his California testimony, he showed
that the data can reject neither hypothesis, so that the data are consistent with a data generating process that is
stationary (constant over time) and has zero mean (so that the input price growth for the telecommunications
industry equals that of the U.S. as a whole).

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The two key questions to be answered are (i) whether LEC input price growth differs from the overall U.S. input price growth over the long run and (ii) whether the input price differential has changed since divestiture from its long run average. One simple way to address these questions is to create an index of each series and observe if, when and how LEC and U.S. input prices deviate from one another. These seemingly contradictory statistical results are then readily explainable given a picture of the data. Figure 1 shows LEC and U.S. input price indices developed using the Christensen 1 data set for the 1949-1992 period.

The input price indices track each other very closely from 1949 to 1979. LEC input prices then grow more rapidly than U.S. input prices from 1980 to 1983, more slowly from 1984 to 1989 and more rapidly again from 1990 to 1992. Relying on an artful choice of dummy variables, one could easily, but incorrectly, conclude that the relationship between LEC and U.S. input prices changed permanently at divestiture, but the evidence shows that (i) the change did not begin in 1984 and (ii) the change was not permanent, reversing itself in the 1990-1992 period. The data simply do not show a one-time, permanent change in the relationship between LEC and U.S. input prices in 1984. From the evidence shown in Figure 1, it would be impossible to argue that the mean input price differential growth rate for the 1984-1990 period would be the best forecast of future input price differential growth rates. On the contrary, the evidence suggests that a one-time deviation from historical norms has reversed itself and that U.S. and LEC input price changes should now again approximately equal one another. If there was a shift, it was temporary and is now over.

In addition, the data used to measure the input price differential were not collected for this purpose and are unsuited for this use in several ways. First, as explained by Dr. Christensen, the U.S. input price series are calculated using a different treatment of capital prices from the LEC input price series. Thus, in the post-divestiture period when interest rates fell but corporate profit rates remained relatively constant, the difference between measured U.S. and LEC input price changes overstated the actual difference between those changes. Moreover, the fact that both Christensen 1 and 2 data sets were spliced together

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essentially at divestiture readily explains the observed "change" in the relationship between
LEC and U.S. input price growth rates.[17] Thus, our ability to measure any hypothetical
shift from these data is limited: measured differences in LEC and U.S. input price growth
rates are at least partly due to differences in measurement methods.

C.   Errors in Measuring Input Price and TFP Growth do not Cancel Out

In USTA's Reply Comments filed in 1994, NERA presented both theoretical and
empirical evidence that differences between measured LEC and U.S. industry input price
growth rates are unreliable and more volatile than corresponding differences between LEC
and U.S. total factor productivity growth rates. In addition, Christensen showed that U.S.
and LEC capital prices were not comparable because they were calculated using different
methodologies, and that apparent differences in growth rates could be ascribed to differences
in methods of calculation rather than underlying differences in the true growth rates.

In their appraisal of this evidence, Bush-Uretsky replied that

- NERA has not shown that measurement errors in capital prices "introduce a
  bias into the input price series"[18] and that "although NERA has shown that
  the measurement problems could cause considerable year to year fluctuations,
  NERA has not shown that such fluctuations could make a six year period ...
  unreliable"[19] and that

- though BLS and Christensen measure capital costs differently, "an opposite
  bias of equal magnitude is contained in the TFP differential that USTA would
  use to set the X-Factor...[so that] the sum of the TFP differential and the input

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[17] The Christensen 1 data set essentially combines Bell System measurements (i.e., AT&T included
with the RBOCs) from 1949-1979 with LEC measurements from 1984-1992, using two different LEC data sets
between 1980 and 1983. The Christensen 2 data set combines the North Dakota LEC study (which uses a
simplified measure of the price of capital) for the 1960-1984 period and the USTA LEC study for the 1985-
1992 period.

[18] However, Christensen Associates showed that the capital price series in the U.S. National Income and
Product Accounts produced a biased measure of the growth of U.S. capital prices and thus of the LEC-U.S. input
price differential. See the Christensen Affidavit at 7-9.

[19] Generally an advocate of the use of a particular statistic for public policy purposes shows that the statistic
is reliable, so that random errors of measurement do not lead to real changes in economic outcomes. NERA's
alleged failure to show that the measured input price differential is unreliable does not meet even that minimal
burden of proof.

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price differential will be unbiased and that the X-Factor, which equals the sum, will be unbiased."[20]

Based on this record, ¶ 59 of the *FFN* seeks further information on problems in measuring input price changes, citing Bush-Uretsky's conclusion that

> descriptions of problems in measuring changes in post-divestiture input prices
> fails (*sic*) to convince us that the problems are serious enough to warrant
> rejection of the measurements for use in calculating an X factor.

This conclusion, however, is incorrect and is based on (i) a misreading of the empirical evidence in the NERA study and (ii) a simple algebraic error in Attachment B to the Bush-Uretsky study.

First, input price differential data are clearly subject to much greater fluctuations than productivity differential data over the post-divestiture period. The empirical evidence regarding the input price differential presented in the various USTA filings and *ex partes* shows clearly that random fluctuations make data from a six or eight year period sufficiently unreliable that standard statistical tests cannot distinguish the mean differential from zero.[21] One might debate in a policy setting whether these statistics should commit the analyst to behave as if the hypothesis were true. However, one cannot seriously debate the empirical fact—quantified by the t-statistics—that "such fluctuations ... make a six year period ... unreliable," particularly for use in predicting future values of the differential.

Second, Bush-Uretsky's conclusion regarding the comparability of LEC and U.S. input price series suffers from a critical algebraic error. In their Equation (2), reproduced below, the authors write the measured input price change ($\%W^{US}$) as the sum of the true input price change ($\%W^{*US}$) and a measurement error in input prices (Δ_w)

(2) $$\%W^{US} = \%W^{*US} + \Delta_w \ .$$

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[20] Appendix F at 11.
[21] See, for instance, the affidavit of Dr. Laurits R. Christensen, "An Input Price Adjustment Would Be An Inappropriate Addition to The LEC Price Cap Formula" on behalf of the United States Telephone Association, February 1, 1995

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The error Δ_W is ascribed to the effect of profits on the measured change in U.S. input prices.[22] Bush-Uretsky define $\%TFP^{*US}$ as

(2.1) $$\%TFP^{*US} \;=\; \%W^{*US} \;-\; GDP\text{-}PI$$

which can be interpreted as the measure of TFP growth associated with a correctly measured input price growth given by $\%W^{*US}$. Substituting equation (2.1) into equation (2), they then obtain

(2.2) $$\%W^{US} \;=\; GDP\text{-}PI \;+\; \%TFP^{*US} \;+\; \Delta_W \;.$$

The error arises in the next step where they (implicitly) assume that the last two terms in the above equation are equal to measured U.S. productivity growth. Using this notation, however, measured U.S. productivity growth ($\%TFP^{US}$) differs from actual U.S. productivity growth ($\%TFP^{*US}$) by a measurement error (Δ_{TFP}):[23]

(2.3) $$\%TFP^{US} \;=\; \%TFP^{*US} \;+\; \Delta_{TFP} \;.$$

Thus errors in measuring national input price growth and national TFP growth would cancel out and measured national input price growth would be equal to measured inflation plus measured national TFP growth:

(2.4) $$\%W^{US} \;=\; GDP\text{-}PI \;+\; \%TFP^{US}$$

only if $\Delta_W = \Delta_{TFP}$. Comparing equations (2.2) and (2.4) above, we see that Bush-Uretsky have implicitly assumed that the measurement error in national input price growth is the same as the measurement error in national TFP growth (i.e., the measured growth rate differs from the actual growth rate by the same amount, Δ, for both U.S. input prices and productivity). Thus, Bush-Uretsky incorrectly conclude that Δ cancels out in their equation (6) in Attachment B only because they incorrectly assume that the same Δ measures both the

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[22] We add the subscript W to Bush-Uretsky's Δ to distinguish measurement error in input price growth from measurement error in TFP growth below.

[23] We add the subscript TFP to Bush-Uretsky's Δ to distinguish measurement error in TFP growth from measurement in input price growth above.

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error due to profits in the U.S. input price growth series and the error due to profits in the U.S. TFP growth series.

The assumption that an error due to the treatment of profits in U.S. accounting has the same effect on measured productivity growth as on measured input price growth is utterly incorrect. As explained in the NERA 1994 Reply Comments,

> In a TFP study, input prices are used only to calculate the relative weights of different inputs used in construction of the quantity index of aggregate input. These weights are expenditure weights, where expenditure is the product of price and quantity. While calculation of labor and materials prices and expenditures is straightforward, the estimation of capital expenditure and the price of capital is quite complex. Moreover, for purposes of a TFP study, capital expenditures do not have to be measured with a significant level of precision: even though there are a number of ways to calculate such expenditures, the capital share of the input quantity index tends to be around 50 percent for LECs. And since it is the level that is important, fluctuations around 50 percent do not matter much in the estimate of the input quantity index.
>
> In contrast, when the same formulas are used to calculate an input price index, the year to year change becomes very important. It is elementary that accurate calculation of changes is much more difficult that accurate calculation of levels.[24]

For example, small changes in capital equipment prices produce large changes in the measured price of capital, (as shown in Table 3 of the NERA Reply Comments) but have little effect on the relative size of capital expenditure and thus little effect on measured TFP. Such distortions are thus likely to have a much more significant impact on the growth of input prices than on the growth of TFP. In general, any error that distorts the *growth* of aggregate input prices but not the proportional mix of inputs will result in different Δs for equations (2) and (2.3) above. Thus, if one were to use the proposed input price differential in the calculation of **X**, measurement errors in national input prices would not cancel out,

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[24] National Economic Research Associates, Inc., "Economic Performance of the LEC Price Cap Plan: Reply Comments," filed as Attachment 4 to the *United States Telephone Association Reply Comments*, June 29, 1994, at 28. (NERA Reply Comments).

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and errors in the input price differential would translate directly into errors in the measured value of X.

In summary, a correct reading of the theoretical and empirical evidence in the record supports the fragility of direct measures of the input price differential over the post-divestiture period. Setting X to reflect random fluctuations in the post-divestiture input price differential runs the risk of seriously penalizing price-cap regulated firms as interest rates begin to rise and LEC input prices—once again—begin to grow at a faster rate than those of the U.S. as a whole.[25]

III. PRODUCTIVITY GROWTH CANNOT BE MEASURED FOR SUBSETS OF SERVICES

The *FFN* explores in ¶s 62-70 the possibilities of (i) measuring TFP growth for interstate services or for regulated services alone or (ii) adjusting a total company measure of productivity growth for differences in the relative rates of output growth for various services. Failing such adjustments, the *FFN* asks whether adoption of a productivity offset based on total firm TFP experience for interstate services alone would result in a deficit or windfall if intrastate prices were regulated using Part 36 costs.

As the *FFN* tentatively concludes,[26] TFP must be calculated on a total company basis because there is no economically meaningful way to assign portions of common facilities to individual services. To see this, suppose the regulated firm supplied only two identical services (interstate and intrastate usage) initially at equal volumes and equal prices, using identical facilities which could have both fixed and variable cost components. Suppose that over time, (i) demand for interstate usage doubled while demand for intrastate usage remained constant, and (ii) total input quantities increased by 40 percent. The resulting growth in TFP for the firm would be about 6 percent; using Törnqvist revenue weights,

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[25] In addition, changes in other LEC input prices could cause aggregate LEC input price growth to exceed that of average U.S. input prices.

[26] At ¶ 63.

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aggregate output would have increased by about 46 percent while aggregate input quantities would have increased by 40 percent. Assuming input prices were unchanged, unit costs would fall by about 6 percent.[27]

How should this productivity growth be distributed—if it all—between interstate and intrastate usage? First, it should be clear by the symmetry of the assumptions that the change in variable cost is the same for interstate and intrastate usage: an additional minute of each service would increase total costs by exactly the same amount both before and after the change in output. Even though interstate demand growth is responsible in this example for the reduction in unit costs, that reduction inures equally to interstate and intrastate services. Thus if all costs were variable, unit costs for interstate and intrastate services would fall by the same amount (6 percent), and—in unregulated competitive markets—output prices for · these services should fall by about the same amount. Second, if all costs were fixed, incremental cost would be zero in each jurisdiction and each additional minute of use would reduce unit costs by the same amount, irrespective of whether the usage were interstate or intrastate. Thus, it is pointless to ascribe faster TFP growth to one service compared with another.

A.   Productivity Growth Cannot be Measured Separately for Interstate Services

The Christensen measures of historical LEC industry total factor productivity growth were calculated for (essentially) all inputs and outputs of the local telephone companies. Noting that the FCC regulates only interstate services, the *FFN* questioned the relationship between productivity growth for the firm as a whole and productivity growth for its interstate and intrastate services. In particular, the *FFN* requested comment on whether differential rates of output growth or profitability between interstate and intrastate services would affect measures of the historical interstate TFP growth rate and if there were some mechanism to adjust total company TFP growth estimates to account for these differences.[28]

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[27] We calculate growth rates using the difference between the natural logarithms of the levels.
[28] *FFN* at ¶ 62-68.

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Because changes in intrastate output affects interstate costs, there is conceptually no way to define TFP growth separately by jurisdiction. And since one cannot define distinct interstate and intrastate productivity growth rates, there can be no adjustment to total company TFP growth to approximate interstate productivity growth.

1.   **Separability imposes restrictions on the production process for a multiproduct firm that do not hold for telecommunications technologies.**

Economic theory shows clearly that TFP growth for subsets of services in a multiproduct firm can be defined only in very restrictive circumstances that certainly do not hold for telecommunications firms. In economic theory, productivity growth is measured with reference to a production function which specifies the maximum output that can be produced from given quantities of inputs. Using that production function, total factor productivity growth is the difference between the rates of growth of a revenue-weighted index of maximum output quantities and an expenditure-weighted index of input quantities. If there were only two outputs: interstate and intrastate services, it would not be meaningful to speak of individual TFP growth rates for interstate and intrastate services unless the production function can be written in a particular and very restrictive form in which:

- all outputs can be unambiguously separated into intrastate and interstate services;

- all inputs can be unambiguously separated into intrastate and interstate factors of production; and

- changes in intrastate inputs do not affect interstate output and changes in interstate inputs do not affect intrastate output.

Mathematically, these conditions imply that the cost function for the firm can be written as the sum of individual cost functions for interstate and intrastate services:

$$C(Q_{inter}, Q_{intra}, P_L, P_K, P_M) = C_1(Q_{inter}, P_L, P_K, P_M) + C_2(Q_{intra}, P_L, P_K, P_M)$$

where P_L, P_K, and P_M are the prices of labor, capital and materials, Q_{inter} and Q_{intra} are quantities of interstate and intrastate outputs and $C_i(Q, P_L, P_K, P_M)$ represents the minimum cost of producing output Q with given factor prices P_L, P_K and P_M. These requirements are

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known as "separability" restrictions in economic theory, and in particular, they mean that the marginal rate of substitution among interstate factors of production must be independent of the level of intrastate demand (and vice versa). The known presence of economies of scope among interstate and intrastate services means that the cost function cannot be separable, and TFP growth cannot be measured independently for interstate and intrastate services.

As recognized in the *FFN*, interstate and intrastate telecommunications services are supplied using a high proportion of common facilities, and such technologies are, in fact, *not* separable in the sense defined above. Interstate and intrastate usage services are produced using the same facilities and expenses. An increase in demand for interstate carrier access leads to precisely the same changes in investment and expenses as an increase in the demand for intrastate carrier access or, indeed, for local usage. In these circumstances, it is impossible to distinguish between the productivity growth rates of intrastate and interstate services. If each additional minute of interstate service requires the same increase in inputs as an additional minute of interstate service, then productivity growth in the two sectors will be the same.

Note that this result holds irrespective of the output growth rates of the two services. Even if intrastate output is constant, if the identical technology is used to produce intrastate and interstate services, interstate and intrastate services would experience the same growth in total factor productivity, in the sense that the change over time in the amount of output produced per unit of input would be the same. An addition to the rate of growth of interstate output would lead to higher total factor productivity growth for intrastate as well as interstate services.

2.   Jurisdictional separations do not provide a basis for productivity analysis

Outputs can be assigned consistently to interstate and intrastate jurisdictions, although the distinction may have little meaning to customers.[29] The difficulty for productivity analysis is that the costs associated with producing intrastate and interstate

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[29] For example, the local distribution of interstate toll calls is jurisdictionally interstate under the Commission's rules, but the calls are functionally identical to the local distribution of intrastate toll calls.

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services cannot be separated into corresponding intrastate and interstate components. The Commission's Part 36 Rules do not jurisdictionally separate costs for the purpose of setting prices. They do not reflect cost causation, and interstate costs do not even approximate the economic costs of supplying interstate services. Productivity growth measures based on separated costs would be distorted by changes in the separations formulas and factors and would provide no meaningful information about the productivity growth of interstate services.

Consider, for example, the recent history of jurisdictional separations. From the beginning, the interstate jurisdiction was synonymous with long distance toll service. Thus costs allocated to the interstate jurisdiction were recovered from long distance charges while costs allocated to the intrastate jurisdiction could be recovered from intrastate usage charges. or from flat-rated monthly charges. Until *Smith v. Illinois Bell* in 1930, none of the costs of local service were assigned to long distance services. The first separations manual was adopted in 1947, and in response to the perceived need to hold down local rate increases, the industry steadily increased the portion of local costs assigned to the interstate jurisdiction.[30] By 1982, the presence of competition in interstate long distance markets made increasing subsidies to local service difficult to sustain, and the FCC froze the subscriber plant factor portion of the separations formula, reducing it to a common 25 percent gross allocator in a transition from 1983 to 1986.

The intention of jurisdictional separations was thus to determine an appropriate amount of local exchange costs to be recovered from long distance revenues. There was and is no pretense that jurisdictionally interstate costs bear any relation to the forward-looking incremental or total costs of supplying interstate services. For example, 25 percent of non-

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[30] The percent of non-traffic sensitive (NTS) plant assigned to the interstate jurisdiction was originally set at the interstate minutes of use (SLU) proportion. This proportion increased steadily between 1950 and 1980 from 1.8 times SLU in the Charleston Plan (1952) to 2.5 times SLU in the Denver Plan (1965) to 3.2 times SLU in the FCC Plan (1968), culminating in 3.3 times SLU in the Ozark Plan (1971). For a history of jurisdictional separations, see James W. Sichter, *Separations Procedures in the Telephone Industry: The Historical Origins of a Public Policy*, Program on Information Resources, Harvard University, Cambridge, Massachusetts, Publication P-77-2, January 1977 or C.L. Weinhaus and A.G. Oettinger, *Behind the Telephone Debates*, Norwood, New Jersey: Ablex Publishing Corporation, 1988.

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traffic sensitive (NTS) accounting costs are assigned to the interstate jurisdiction even though these costs are not sensitive to the volume of interstate services or even to the presence or absence of interstate services in their entirety. Measures of productivity growth for interstate services would be affected by the rate of growth of NTS plant, and yet there is no causal connection between the growth of interstate output and changes in NTS plant.

When the production process is not separable between interstate and intrastate services, interstate TFP growth is undefined. Measuring it is like trying to find a black cat in a dark room where there is no cat. It is not merely very difficult; it can't be done.

If it could be done—though it can't—any method of measuring jurisdictionally interstate TFP growth would have to adjust investment and expenses for changes in the separations rules. Obviously a change in a separations formula that shifts investment or costs towards the interstate jurisdiction does not represent a reduction in interstate productivity growth in any meaningful sense of the word. In addition to adjusting for changes in the rules, additional adjustments would have to be made for ordinary changes in separations factors. The Commission's Part 36 Rules assign investment and costs to the interstate jurisdiction depending on factors such as the percentage of interstate use. In practice, special studies are performed by telephone companies at various intervals of time to calculate factors to be used in the formulas. A change in a factor would change measured productivity growth—all else equal—and since the change in the factor bears no necessary relationship with a change in the forward-looking economic cost of supplying interstate service, such changes would also bias the measurement of productivity growth.

In short, the jurisdictional assignment of costs through Part 36 of the Commission's Rules does not represent an economically meaningful assignment of costs to the categories corresponding to outputs of interstate and intrastate services. Changes in separated costs or investment generally have no bearing on corresponding changes in the relative costs of interstate and intrastate services, and using such costs in a TFP study would produce economically meaningless results. As long as interstate and intrastate services are produced using common costs and the same technology, there is no way to identify separate productivity growth rates for interstate and intrastate services.

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3. Different output growth rates for different services do not imply different productivity or unit cost changes.

It is generally recognized that output growth is a key determinant of the rate of growth of TFP. For example, the 1989 NERA study filed in CC Docket No. 87-313 found that a one percent increase in the rate of growth of usage was associated with about a 0.5 percentage point increase in the rate of growth of TFP.[31] Similar results were reported in the Christensen study for local exchange carriers filed in 1994; that study concluded that "a one percentage point decrease in output will lead to a reduction in TFP growth of between .3 and .5 percentage points."[32] With this background, the Commission seeks comment in the *FFN* (at ¶ 65) regarding adjustments that might be made to an aggregate firm-level historical TFP growth estimate to reflect differences in intrastate and interstate service growth rates.

First, it is important to understand the observed relationship between rates of growth of output and rates of growth of TFP. Faster growth in usage (interstate or intrastate), for example, leads to a more rapid replacement of network switches and trunks which are common facilities used to produce both interstate and intrastate usage services. Hence more rapid interstate output growth leads to more rapid total company productivity growth. In exactly the same manner, more rapid intrastate usage growth leads to the same increased growth in total company TFP. Thus, even if interstate and intrastate services were separable (so that we could identify separate productivity growth rates—which we cannot), their TFP growth rates would be the same and would not depend on which service was actually growing more rapidly over any particular historical period.

Second, suppose that interstate and intrastate message *usage* services were identical (and thus experienced identical historical TFP growth rates). An additional component of overall intrastate output is related to lines, and it is correct that the growth in lines has

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[31] National Economic Research Associates, Inc., "Analysis of AT&T's Comparison of Interstate Access Charges Under Incentive Regulation and Rate of Return Regulation." Filed as Reply Comments regarding the FCC's *Report and Order* and *Second Further Notice of Proposed Rulemaking* in CC Docket 87-313, August 3, 1989.

[32] L.R. Christensen, P.E. Schoech, and M.E. Meitzen, "Productivity of the Local Operating Telephone Companies Subject to Price Cap Regulation," Christensen Associates, May 3, 1994, p. 23.

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significantly lagged the growth in usage services over the post-divestiture period. Does the inclusion of line-related services in the measure of intrastate output suggest that interstate TFP growth—if identifiable—would be greater than the aggregate firm TFP growth? The answer is no because the production process of a multiservice telecommunications firm cannot be separated between line and usage-related outputs.[33] If the production process is not separable, it makes no sense to speak of productivity growth for lines or usage individually.

In conclusion, TFP growth is undefined for intrastate and interstate services, and attempts to adjust aggregate measures of TFP growth to offset differential rates of output growth or different average margins between price and cost can only be described as arbitrary. Because separate productivity growth rates for interstate and intrastate services do not exist, it is futile to ponder how to adjust an aggregate TFP measure to approximate the non-existent separated growth rates.

B.   Productivity Growth Cannot be Measured Independently for Regulated and Nonregulated Services Produced Using Common Facilities

The FCC 1987 *Joint Cost Order*[34] established rules (set out in Part 64 of the Commission's Rules) to separate costs of regulated and nonregulated services, including both incremental costs that can be assigned on a cost-causative basis and common costs that cannot. The Order requires large LECs to file cost allocation manuals (CAMs) that detail each company's implementation of the rules and to submit to an annual independent audit to attest that the firm complies with the manual. Like the Part 36 jurisdictional separations rules, these Part 64 rules assign costs to regulated and nonregulated services on an other-than-cost-causal basis.

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[33] Some important cost-reducing technical changes are common across lines and usage, e.g., developments in optical fiber transport and in installation and maintenance savings through process re-engineering initiatives.

[34] *Joint Cost Order*, 2 *FCC Rec.* at 1298.

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However, unlike the Part 36 rules, FCC accounting rules do avoid splitting revenues and costs of regulated and unregulated services that share facilities or costs. According to the Part 32 accounting rules, revenues and expenses are booked to accounts within the regulated telephone company whenever the function in question entails costs that are common with the production of a regulated service. Only when production of the service has no shared or common costs with a regulated service would its revenues and expenses be recorded in a separate set of accounts.[35] Part 64 rules are then used to allocate the balances in accounts between regulated and nonregulated sectors, and Part 36 rules are applied to the regulated balances remaining in these accounts (sometimes called "subject to separations" accounts) to effect jurisdictional separations.

Paragraph 70 of the FFN suggests that because

> (w)ith respect to other unregulated services, however, the production functions may differ substantially from those of regulated services since nonregulated services include foreign service offerings and noncommunications services

it might be

> possible and reasonable to exclude some or all nonregulated services from the TFP calculation even though we decide to include intrastate services in the calculation.

To the extent that Part 32 accounting rules recognize and idenify when regulated and nonregulated services share no common costs or facilities, it is reasonable to treat the production function of the telephone company as separable between regulated and nonregulated services—in the sense that its cost function can be written as the sum of independent cost functions for the aggregate of regulated services and the aggregate of nonregulated services. Under no likely conditions, however, could Part 64 separated data be used to measure the costs attributable separately to individual regulated or unregulated services because of the existence of a shared production funtion (joint and common costs).

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[35] See, e.g., 47 CFR Section 32.4999(l).

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IV.   THE HISTORICAL REVENUE METHOD SHOULD NOT BE USED TO SET A PRODUCTIVITY TARGET

Although it tentatively adopted the TFP-based approach for establishing the X factor, the FCC is seeking comments on a number of other approaches, including the Historical Revenue Method.[36] In particular, Issue 2a asks:

* Is the Historical Revenue Method Superior to a TFP-based approach for developing an X-factor?

The answer is no. The Historical Revenue Method provides perverse productivity incentives: essentially the same disincentives of traditional cost-plus regulation. In addition, the deviations between accounting and economic costs introduce serious measurement errors so that the method is an extremely poor approach to establish a productivity factor for a price cap plan.

We elaborate by addressing the specific issues addressed in ¶s 80 - 83. In particular, ¶81 deals with the fundamental issue of incentives, and ¶ 83 deals with the mathematical basis for the approach. Paragraphs 80 and 82 address implementation details in the event that the approach is adopted. We address the paragraphs in this order.

A.   Productivity Incentives

Paragraph 81 asks: "Does the Historical Revenue Method provide adequate incentives for LECs to increase productivity and become more innovative?" The answer is no. As we explained in NERA's June 1994 reply comments, because this method resembles traditional regulation, it does *not* provide proper efficiency incentives. We repeat our earlier analysis of this issue here.

In the 1994 review, several parties asserted that LEC earnings had risen under the price cap plan or were simply too high, and they proposed an increase in X to resolve these problems. Both AT&T and GSA based their productivity offset recommendations on a direct assessment of the LECs' actual accounting earnings performance during the price cap period.

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[36] The method was proposed by AT&T (and also GSA) and has been called the Direct Method by its proponents.

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While employing somewhat different methodologies, both answered the question: what would the X factor have to have been for the LECs to have earned the target return (11.25 percent) during the price cap period. Both then proposed a mid-course adjustment to the Commission's productivity offset based on that calculated historical X.

That proposal represented a gross misunderstanding of how incentive regulation works; if implemented, it would eviscerate the Commission's attempted regulatory reform and institute in its place, traditional cost-plus regulation with a three-year lag. The very design of incentive regulation requires that the LECs *not* be required to forfeit the entirety of the gains obtained from their own improved performance. Hence measurements of achieved productivity growth should have only a *limited* role: to serve as a diagnostic measure of whether the original parameters of the plan were seriously in error. There are two reasons for this limitation:

(i) productivity growth exhibits fairly large year-to-year variations, so that most observed deviations from the expected value are well within the normal range. It would be senseless to vary parameters of the plan to track random fluctuations in annual productivity growth; and

(ii) unusually large productivity gains could be the result of management effort. Adjusting the plan subsequent to this effort would severely erode the incentives of the plan to the point of creating a thinly-disguised version of traditional cost-plus regulation.

The original price cap plan contemplated a wide range of acceptable earnings outcomes: a floor was established at 10.25 percent, 50/50 sharing of earnings would begin at 12.25 percent, and earnings were capped at 16.25 percent. Earnings within this range were permitted to deviate (up or down) from 11.25 percent, and the acceptable degree of deviation was not unintentional. Indeed, it constituted the essential difference between the price cap plan and ordinary rate of return regulation. If the range of acceptable earnings outcomes had been smaller—e.g., if it shrunk to zero (around 11.25 percent)—the price cap plan would

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have operated exactly as theoretical rate of return regulation.[37] The price cap formula would have adjusted prices every year, but earnings adjustments would have ensured that prices in total changed just as they would have changed had rate of return regulation continued. Thus earnings that deviated from 11.25 percent but remained in the range contemplated by the plan were not considered excessive or deficient, and allowing earnings to deviate from 11.25 percent is an essential component of the plan.

It is noteworthy that according to AT&T's data presented in the 1994 Review, no RBOC's rate of return fell outside this range, averaged over the price cap period. In fact, the average rate of return for the price cap companies fell comfortably in the center of the range. Adjusting a plan on the basis of actual outcomes that are clearly within the range contemplated by the plan would have simply been a return to the bad old days of traditional cost-based regulation, which the Commission rightly rejected as antiquated and in need of change.

Another problem with using earnings in the way contemplated by the historical revenue method is that LEC earnings—as measured by regulatory accounting rules—do not pretend to measure economic profit and are notoriously poor proxies for it. Moreover, changes in accounting earnings are also a poor measure of changes in economic profit. First, economic profit is not defined for interstate services because there is no economic basis upon which to split common costs between interstate and intrastate services. Second, the accounting treatment of depreciation for regulated LECs is based on asset lives that are currently too long and have historically been too long, so that LEC accounting profits are overstated relative to economic profits. As telecommunications markets become more competitive, market forces will undertake a more realistic appraisal of the LEC capital stock, and as asset lives are reduced, the associated changes in accounting profits will be again a poor measure of changes in economic profits.[34] Third, regulated earnings are affected by numerous accounting conventions, so that a firm's decision to accelerate the depreciation

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[37] This result holds irrespective of the level of the authorized rate of return. If the acceptable range of earnings shrank to zero around 12.25 percent, the outcome would be indistinguishable from cost-plus regulation using 12.25 percent as the authorized rate of return.

[34] See, for example, Riva Atlas, "Honesty isn't such a bad policy," *Forbes*, July 4, 1994, p. 118.

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expense associated with an asset would affect measured productivity growth in this method but would not, in reality, affect the growth rates of outputs, inputs or actual productivity.[39]

A second problem with inferring a productivity differential from earnings data is that the calculation presupposes that all other aspects of the plan perform correctly. In particular, if some exogenous cost changes—positive or negative—were not accounted for under the price cap plan or if their effect on costs beyond their effect on the GDP-PI were calculated incorrectly, one could no longer infer the level of the achieved historical productivity offset from data on earnings.

Because price cap regulation decouples prices from accounting costs, regulated firms operate under efficiency incentives similar to those facing unregulated firms. However, the efficiency benefits from price caps depend on managers having confidence that superior cost savings will not ultimately be taken away through inappropriate adjustments to the plan. For example, if management believed that superior realized productivity would trigger an increase in the productivity target in the future, the efficiency incentives would be severely eroded.

While the actual performance (including the change in productivity) of the LECs during the price cap period may be germane to the review of the program, the results must be interpreted in the context of the Commission's intent in establishing the plan. In order to ensure long-term stability and to avoid a return to traditional cost-plus regulation, it is absolutely essential that the productivity gains realized under price caps not be used to recalculate a firm's price cap productivity target. For example, suppose the LEC industry implemented a cost-saving program that lowered the *level* of inputs by one percent, but did not affect the rate of change in inputs in the future. Such a change would show up as a one percent improvement in productivity in the year it occurred. If this measurement caused the productivity target to increase by one percent, the LECs would be forced to give back their

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[39] A TFP study—like the Christensen Associates study filed in this Docket—that uses economic depreciation in its calculation of the capital stock is not affected by these accounting conventions that would distort the type of analyses presented by AT&T and GSA and now referred to as the Historical Revenue Method.

Method.